Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

CANMET
Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

UNDERGROUND TRIALS WITH THE McPHAR 'STRESSALERT' ROCK STRESS MONITOR AT LINGAN COLLIERY

Peter Cain and Stephen Forgeron

DECEMBER 1982

MICROMEDIA

This document is an unpublished interim report pr... to ... and Energy ... (CANMET)

Ce document est un rapport ... publié et révisé ... aux fins de ... (CANMET)

DEC 22 1983

14pp

ENERGY RESEARCH PROGRAM
COAL RESEARCH LABORATORIES
SYDNEY, NOVA SCOTIA
DIVISION REPORT ERP/CRL 82-15(IR)

UNDERGROUND TRIALS WITH THE McPHAR 'STRESSALERT' ROCK STRESS MONITOR AT LINGAN COLLIERY

by

Peter Cain* and Stephen Forgeron**

SUMMARY

This report gives brief details of the McPhar 'StressAlert' rock stress monitor and trials conducted with it by CBCRL/CBDC staff at Lingan Colliery, Cape Breton.

The results obtained were inconclusive due to the short length of time monitored at each site, the nature of the recording device available and communications problems experienced at one of the sites.

It is concluded that before an instrument be purchased for monitoring in situ stress changes, further investigations are carried out. Some proposals are outlined.

---

*Research Scientist, Cape Breton Coal Research Laboratory, CRL, CANMET, Energy, Mines and Resources Canada, Sydney.

**Senior Geologist, Cape Breton Development Corporation

ESSAIS SOUTERRAINS AVEC LE MONITEUR DE TENSION DES ROCHES "STRESSALERT" DE MCPHAR À LINGAN COLLIERY

par

Peter Cain* et Stephen Forgeron**

SOMMAIRE

Le présent rapport décrit brièvement le moniteur de tension des roches "StressAlert" de McPhar et résume des essais effectués avec cet instrument par des chercheurs du LRCCB et de la CPDC à Lingan Colliery, Cap-Breton.

Les résultats obtenus n'étaient pas concluants en raison de la brièveté du monitorage à chaque site, du type d'enregistreur disponible et de problèmes de communication à l'un des sites.

On conclut qu'il est nécessaire de poursuivre les recherches avant d'acheter un instrument pour le monitorage des variations de tension in situ. Certaines propositions sont avancées.

---

*Chercheur, Laboratoire de recherche sur le charbon du Cap-Breton, LRC, CANMET, Énergie, Mines et Ressources Canada, Sydney.

**Géologue principal, Development Corporation de Cap-Breton.

CONTENTS

	Page
SUMMARY	i
SOMMAIRE	ii
INTRODUCTION	1
THE McPHAR 'STRESSALERT' ROCK STRESS MONITOR	2
The Sensor	2
The Instrument Pack	2
Processor Function	3
Operational Experience	3
THE UNDERGROUND TEST PROGRAM	4
CONCLUSIONS	5
RECOMMENDATIONS	5
REFERENCES	6

ILLUSTRATIONS

Fig.		
1.	The McPhar "stressalert" rock stress monitor	7
2.	Typical Energy and Event data anomalies preceding roof falls	8
3.	Typical stress factor anomalies preceding roof falls	9
4.	Location of test points at Lingan Colliery	10

INTRODUCTION

Noises emitted from coal mine strata in response to stress changes range from the familiar and plainly audible 'pouncing' heard as mining progresses to very high frequency inaudible ultrasonic emissions. Investigations by the United States Bureau of Mines (USBM) have found that micro-seismic signals tend to be quite broadbanded[1];therefore, within some limits any portion of the band can be chosen for study. Using only the higher frequencies allows the removal of most interfering noise such as personnel movement and equipment noise, which has been reported to occur mainly in the frequency range 0.1 - 2.0 KHz[2].

Tests by the USBM using commercially available equipment indicated that micro-seismicity in the 30 - 120 KH3 range provided the most promising avenue of development, and so a custom-built micro-seismic monitor was developed by Integrated Sciences, Inc. of Colorado under contract, and successfully tested in United States Coal Mines[3].

The commercial version of the device is manufactured by McPhar Mine Systems, Inc., of Toronto, who invited the Cape Breton Development Corporation (CBDC) to test it in the Sydney Coalfield in order to establish areas of usefulness.

A short test program of two days duration was planned in association with the Cape Breton Coal Research Laboratory (CBCRL) at Lingan Colliery involving personnel from CBDC, CBCRL and McPhar Mine Systems, Inc. First trials were conducted in an operating room and pillar section to evaluate the manufacturer's claims that the stressmeter response was unaffected by machine noise. Subsequent trials on longwall sections were to try to assess the response of the stressmeter to the setting of a hydraulic face support and to gob caving action. Due to the unsuitability of the only intrinsically safe chart recorder available and several production problems, the results obtained were inconclusive. Nevertheless, some useful information was forthcoming, and it is on the basis of this that the conclusions and recommendations were made.

THE McPHAR 'STRESSALERT' ROCK STRESS MONITOR

The McPhar 'StressAlert' rock stress monitor consists of two units, the sensor and the instrument pack, and includes an internal rechargeable 6V battery unit (Fig. 1). The instrument weighs 14 kg. and can operate unattended for up to ten days. It is certified for use in Canadian underground coal mines.

THE SENSOR

The sensor unit consists of a lithium sulphate crystal and preamplifier fitted to a spring loaded assembly for fixing to a roof bolt or other mounting. The lithium sulphate sensor has a flat response to a range of frequencies betweeen 10 - 110 KH2[(1)]. Output from the preamplifier is directed through a 10 m cable to the instrument pack.

THE INSTRUMENT PACK

The instrument pack comprises of four units. The detector unit receives the signal from the sensor unit, filters out the unwanted frequencies and distinquishes individual seismic events above a preset threshold level before the signal is released to the processing unit.

The processor unit totals the number of events and an approximation of event energy over a period of sixty seconds. If preset threshold levels for event counts or a derived 'stress factor' are exceeded the warning indicator unit is activated.

The warning indicator unit has an amber flashing 'alert' state which is activated if the event count exceeds the preset threshold for five consecutive count periods. If the event count then drops below a second, lower threshold, the red flashing 'warning' state is activated. The 'warning' state is activated immediately if the 'stress factor' threshold is exceeded.

The fourth unit is a rechargeable interchangeable 6V battery.

PROCESSOR FUNCTION

The processor simultaneously performs two functions on the incoming signal. The signal passes through an envelope detector. The envelope detector produces one count for each micro-seismic event that exceeds the threshold level. The second type of processing is energy processing, in which the signal is rectified and then passed through a threshold detector. The threshold circuitry counts a high speed oscillation whenever the threshold is exceeded. This time above threshold was found by USBM to be a good first order approximation of the micro-seismic energy.

The event and energy counts are accumulated for a period of sixty seconds, at the end of which time the 'stress factor', energy count divided by event count, is calculated. Either the energy count or the stress factor may be displayed on an integral digital readout, or both signals may be directed to chart recorders. If the preset threshold levels described above are exceeded, the warning indicator unit is activated.

OPERATIONAL EXPERIENCE

A full review of tests conducted with the prototype of the 'Stress-Alert' monitor has been published[3]. In the course of these tests, it was firmly established that the rock noises processed by the instrument were the direct result of stress changes, such as those brought about by the removal of coal or the stabilization of the roof due to bolting. Anomalies in the energy and event data such as those seen in Figure 2 frequently preceded roof fall events. Of the two, energy data provided a more consistent indicator of impending falls, although the prefall warning time was variable. A more promising approach was found to be the use of the 'stress factor' ratio described above. Some typical plots are illustrated in Figure 3.

It was discovered that the transducer responds to micro-seismic events caused by stress field changes in its immediate vicinity, rather than events associated directly with the impending roof fall. Badly broken roof and large bed separations, which prevented stress field changes from affecting the rock in the vicinity of the transducer were found to limit the system severely.

THE UNDERGROUND TEST PROGRAM

The following locations were selected for testing the rock stress monitor (Figure 4).

1) Room 44 in the room and pillar section.
2) The 4W District materials level face-end.
3) The 3W District coal road face-end.

In each case the monitor was set up according to the manufacturers instructions, except that the event threshold was set only just above background (in normal use it is set well above background to remove all unwanted 'noise'). The monitor was used in conjunction with a 'Seiger' chart recorder of the type normally used to record the output from the BMI methane detector. Event or stress factor counts were recorded every sixty seconds from the monitor's digital readout, whilst the stress factor was continuously recorded on the chart.

Results were obtained for periods of 2 hours, 40 minutes and 1 hour, 40 minutes at sites 1 and 2 respectively. Site 3 was monitored for only a few minutes, as it soon became clear that coal face operations were suspended at that location for the remainder of the shift.

At both sites 1 and 2 the results obtained were inconclusive. No anomalies associated with roof falls were recorded and neither the event count nor the stress factor readings appeared to show any pattern.

At site 1, coal cutting and roof bolting machines worked in close proximity (5-15 m) to the sensor with no noticeable effects on the reading, supporting the manufacturers claim concerning low interference. It was noticed, however, that even slight movement of the cable from the sensor to the instrument pack would move the sensor sufficiently to cause a large jump in both the event and stress factor counts.

At site 2, it had been proposed to try to monitor the effects on the roof of increasing the setting pressure in a powered support, but the necessary synchronization between the hydraulic power pack control and the support setting was not obtained due to inadequate communications facilities and the results were undecipherable.

At both sites it was found that the chart recorder had insufficient resolution to enable individual readings to be read.

CONCLUSIONS

From the underground test program, the following conclusions can be drawn:

1) The test of the stressmeter was not extensive enough to allow a proper evaluation.
2) The test programme did not allow continuous monitoring at one site, which detracted from the results.
3) The BMI chart recorder was inadequate for the use to which it was put. (McPhar released details of a chart recorder compatible with the stressmeter in early 1983)
4) The cable connecting the sensor to the instrument pack is particularly sensitive to movement, which may be significant in strong ventilation currents or active transport routes.
5) The manufacturers claim that the instrument is not affected by proximate mechanical activity appears valid despite the limitations of the test.

RECOMMENDATIONS

Unfortunately the only operating room and pillar section in CBDC mines was closed in March 1983.

USBM results show a tentative use for the 'StressAlert' in retreat longwalls and further possibilities may exist. However, the instrument is restricted to areas of fairly competent roof with little bed separation or deterioration, which effectively rules out its application in advancing longwall gateroads and in Prince Mine retreat longwalls. In both instances, poor roof conditions predominate.

The most likely application would be in monitoring drivages in the solid. At No. 26 colliery the deeps development headings are overlain by a sandstone unit which will on occasion 'burst' releasing material and gas into the heading. These bursts have until now been triggered by shot-firing, but as workings progress deeper (for instance at the new Lingan and

Glace Bay Mines) this might not be the case and a warning system might be required. In this case, it is recommended that a more basic micro-seismic monitoring system be installed to analyze all frequency ranges before any particular warning system is chosen.

REFERENCES

1. Steblay, B.J. "Progress in the Development of a Micro-Seismic Roof Fall Warning System"; Proc. Xth Annual Institution on Coal Mining Health Safety and Res., Virginia, 1979.

2. McKavanagh, B.M. and Enever, J.R. "Developing a Micro-Seismic Outburst Warning System"; CSIRO Div. App. Geomech, Melbourne, Australia.

3. U.S.B.M. "Micro-Seismic Roof Fall Warning System Development, Field Trials and Commercial Prototype Fabrication"; Final Resport USBM Contract No. H0272009.

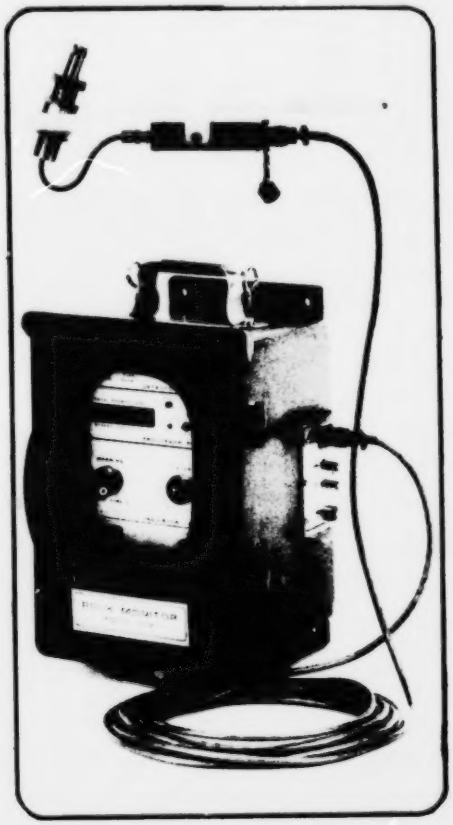
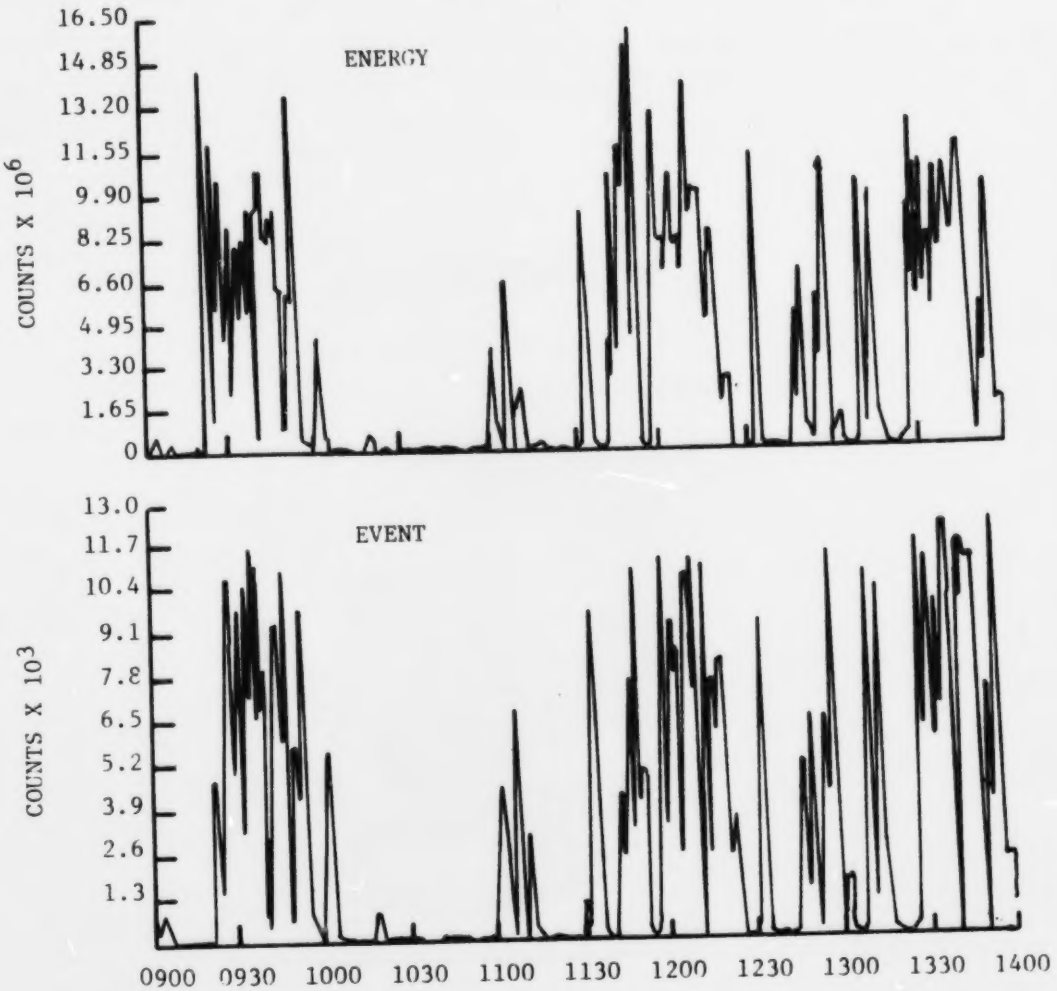
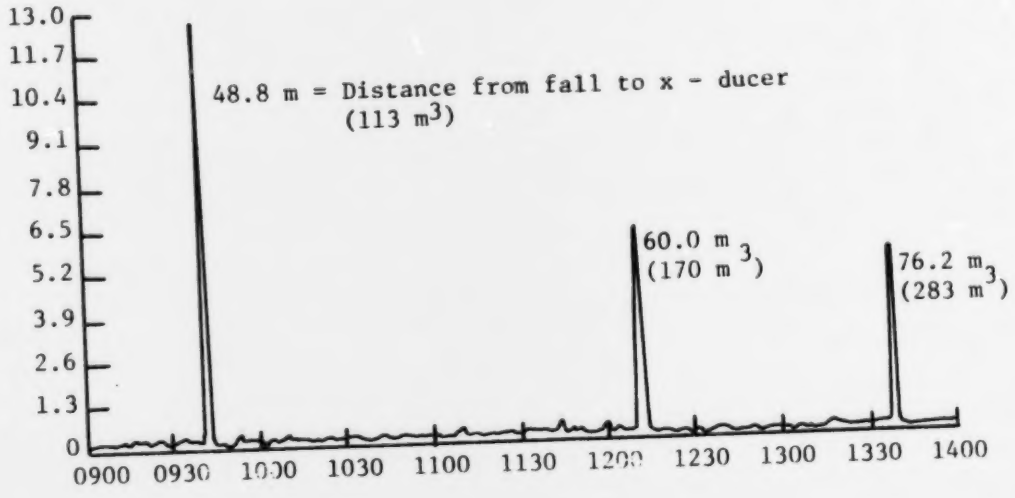


FIG. 1 - THE McPHAR "STRESSALERT" ROCK STRESS MONITOR



Event and energy plots for roof fall sequence on September 15, 1978. (3 falls were reported by section crew, but exact times were not determined). Counts are taken for one minute intervals. (after Steblay, 1979)

FIG. 2 TYPICAL ENERGY AND EVENT DATA ANOMALIES PRECEDING ROOF FALLS



Stress factor plots for a roof fall sequence on September 15, 1978. (3 falls were reported by section crew, but exact times were not determined). Counts are taken for one minute intervals. (after Steblay, 1979)

FIG. 3 TYPICAL STRESS FACTOR ANOMALIES PRECEDING ROOF FALLS

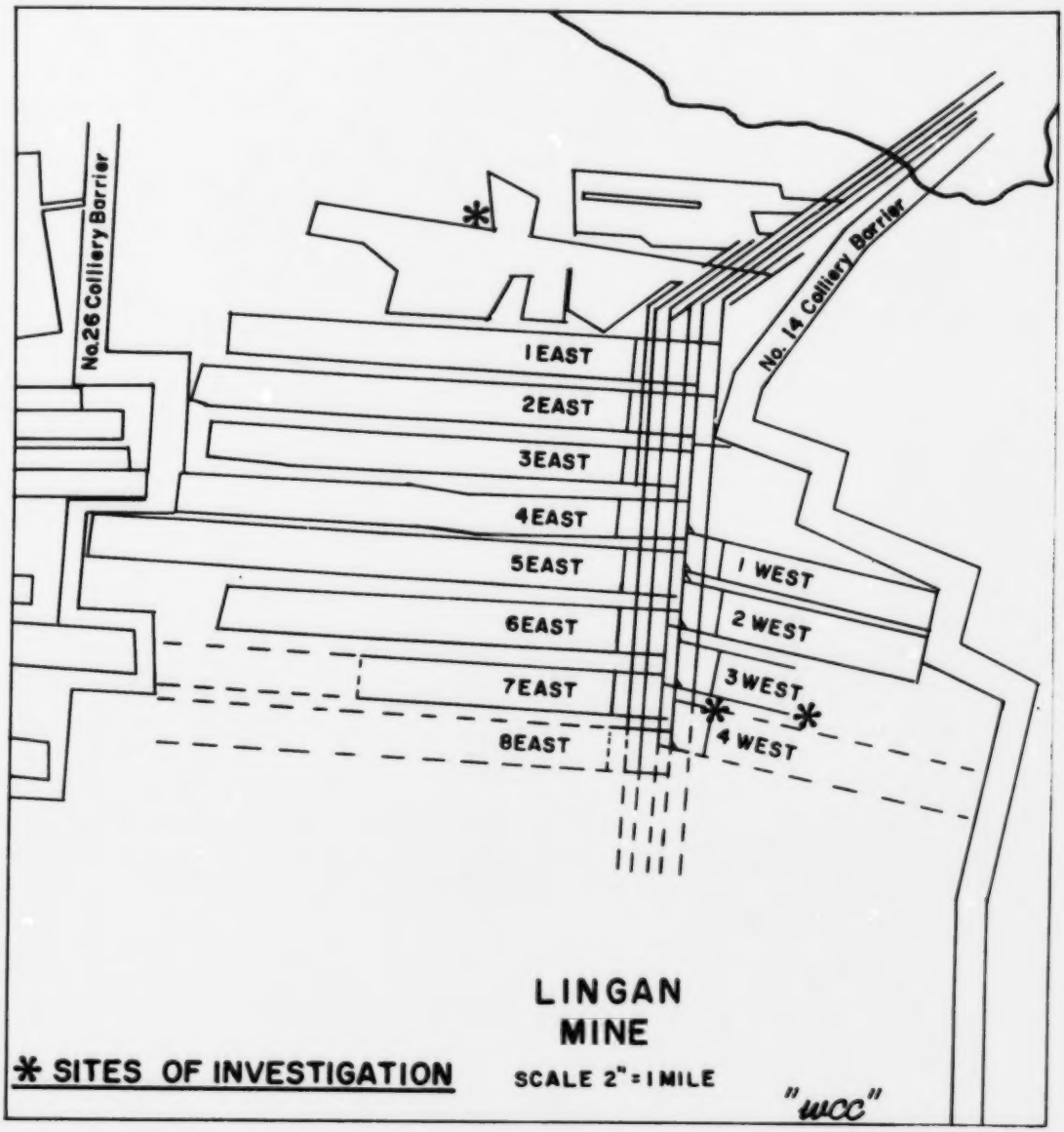


FIG. 4 - LOCATION OF TEST POINTS AT LINGAN COLLIERY